

# Harbor Bar Improvements.<sup>1</sup>

---

BY L. M. HAUPT, C.E.

---

THAT the prosperity of a nation is measured largely by and dependent upon its commerce is proven by the history of the maritime countries of the world. Probably the most renowned instance on record is to be found in the astonishing growth of the Venetians in wealth, power and influence. Located in an out-of-the-way corner of the Adriatic, and surrounded by a labyrinth of islands and lagoons, Venice rapidly expanded from her straw-thatched huts to her marble palaces, while her navy defied the world for well-nigh fourteen centuries.

The ocean is the highway of nations, and her gateways are the ports which indent her borders. Where these portals are spacious, safe and unobstructed, there will commerce thrive, and the greater the number of such gateways, the more fully will both internal and international comity be developed.

The Nicaragua Canal, like her oriental sister at Suez, will be a diadem in the girdle of the earth, binding the East and the West, the North and the South, more closely together by thousands of miles, and thus hastening the time when the civilization and influence of the great Anglo-American commercial nations shall pervade the world.

"Peace hath her victories no less renowned than war," and such victories as these are most potent factors in removing the *casus belli*.

It is a well-known fact, however, that the unceasing forces of nature, the winds, waves, tides and currents, aided by gravity, have bolted these gates by bars which have taxed the ingenuity of man for centuries to unloose; for man and his works are finite, but the sea is the work of the Infinite, and His forces endure through ages. If the barriers may not be removed, at

---

<sup>1</sup> Reprinted from the *Journal of the Franklin Institute*, July, 1889.

least in part, or a pathway be opened through them, then must commerce and the nations languish. Hence the momentous importance of the problem and the justification for the expenditure of millions in the attempt to solve it.

In making this attempt, however, it would seem to be necessary that judicious regard be paid to the lessons of experience, and that past failures should not be repeated under similar conditions.

The old world is full of instructive precedents as to the operations of the various systems which have been tested for generations, and the new world seems bent upon repeating these extravagant experiments, only on a grander scale.

According to the highest official authority in the United States, the methods available for the treatment of these important works for harbors on alluvial coasts are but two in number, namely, "by dredging alone, or by using tidal scour between jetties, aided, if necessary, by dredging. As to the first method, it has already been tried unsuccessfully." As to the second, the same authority states: "The jetties should be so placed as to secure the greatest tidal scour practicable without seriously injuring the interior harbor, and without greatly endangering the safety of the jetties against undermining, or of Galveston Island from overflow in great storms. The greatest scouring effect will be obtained, and the greatest security against undermining, by making the jetties tight and by raising them above high water."<sup>1</sup>

These latter conclusions were only reached after a score of years had been spent in experimentation, at a cost of \$1,576,337.12, and the result to date has been no increase of depth over the bar, but a hastening of the anticipated evils, so that to-day the total estimated cost of this single project is \$8,478,000. After so great an outlay and the lapse of the years required to complete this work, what result may be predicted? The authorities say, "Such a jettied channel offers more resistance to inflow than does the present entrance; reduces the present tidal prism about one-third; allows the bay to fill more slowly than the present entrance does, and hence gives greater differences of level," and they add in closing their report, "The jetties will diminish the freedom of inflow at Galveston." In

<sup>1</sup> *Ex. Doc. No. 85. House of Representatives, Forty-ninth Congress, First Session. Page 13.*



short, they will violate the fundamental requirements of the greatest freedom of influx to the flood tide that there may be a full prism for the ebb scour, and yet with these admissions before them the people of the State of Texas, trusting to this forlorn hope, appeal urgently for the rapid completion of the project.

Is this the *dernier ressort* of the profession of engineering in this nineteenth century, and must we follow blindly the precedents of the middle ages, modified only by the materials of modern times? If so, there are few places, indeed, of sufficient importance as to justify the great expense required for annual dredging and maintenance.

The difficulties surrounding these questions, as seen by the Board of United States Engineers, are expressed in the following extracts from a report on one of the Texas passes:

"The problem of the improvement of the navigation of this pass is by no means an easy one. Some of the difficulties may be mentioned, viz., the want of stability in position of the pass itself; \* \* \* the instability of the foundation on which any structure is to be built; the shifting sand of the Texas coast; the presence in the water in which any structure must be placed of the sea worm (teredo) in such activity that wood cannot be used except to a very limited and exceptional extent, if at all; the necessity of bringing stone, cement, etc., from long distances and at much expense; the heat and other discomforts of a tropical climate increasing the cost of labor." In suggesting a method of procedure the Board say, "The first step in the improvement is to adopt some means of checking the recession of the island which limits the pass on the western side. \* \* \* As the work progresses experience will probably suggest variations of detail. There is a good prospect of success in deepening the channel by the use of two jetties. The locations for them, as recommended, are approved subject to such change as further study may show to be expedient."

Notwithstanding these exceptional difficulties, the plan of jetties in pairs, founded upon brush mattresses, is adopted, yet the report bears inherent evidence of doubt as to method, location, material and results; in fact, the day after signing it, one of the most experienced officers of the Board writes: "I wish it to be understood that with the information now before me I believe one jetty *may* suffice at this locality." \* \* \* "The

views of (the officers in charge)<sup>1</sup> on the subject of the form in plan of jetties are clearly and strongly put, but I do not coincide in them entirely, either in general application or in particular at this locality."

The soundness of this opinion, which would reduce the cost of the work about one-half and increase the probability of securing deeper water, are based upon a few physical characteristics of this and other inlets. They are, the general direction of the resultant of the forces acting along this coast, which produces a gradual yet constant progression of the inlets to the south and west at the rate of about 200 feet per annum, and the flexure of the ebb channel, where it crosses the bar, in the same direction. These obstructions are not delta bars formed by the deposition of sediment from the interior drainage area, but are drift bars composed of beach sand rolled along by the waves and littoral currents, as affected by the incoming tides, and checked abreast of the opening through the outlying sandy cordon. The ebb currents being obstructed by the deposit are turned to the southward and effect their escape along the line of least resistance, which hugs the lee shore and has a direction nearly at right angles to that of the flood component.

Thus, the source from whence comes the sand forming the bar being known, the remedy would seem simple, and the first requirement would be to keep the sand out of the ebb channel by a suitable obstruction, which would not seriously oppose the free ingress of the tide.

The barrier must be placed between the source of supply and the channel. What must be thought then of a policy which invariably directs the construction *first* of the jetty on the farther side, where its effects are soon manifested by the large shoals created in the natural path of the ebb currents, and which they are obliged to roll on, if possible, into deeper water, thus pushing the bar seaward, adding to the ultimate cost, increasing the undermining of the work, and finally burying it under the original bottom? As well might a snow fence be placed on the wrong side of a railroad cut to prevent it from filling with snow. These results are not idle speculation, but oft-repeated facts, proven by surveys; for example, in a report on the jetty partially built upon the *south* side of one of the Texas

---

<sup>1</sup> The writer has omitted names to avoid the appearance of personalities.



inlets, the officer in charge says that "out of the total length of 5,253 feet of jetty constructed, about 775 feet, built upon shore, and constituting a root to the jetty rather than the jetty itself, has been well maintained; 1,710 feet has diminished in height from 47 to 85 per cent., and the remaining 2,768 feet (over half a mile) has practically disappeared. The trenches which have been formed at the sides of the portion of the work which remains, constitute a disadvantage in its further prosecution, which more than counterbalances the advantage of utilizing the material now in place. \* \* \* It will be economy to abandon the present site and lay out a new line parallel with the present one and about 250 feet west of it. \* \* \* "The lightness of the structure and the teredo are not sufficient to account for this. (The injury to the site.) Neither of these causes could have placed the mattresses where they are now found, below the original bottom and buried in the sand." \* \* \*

"It is possible, but not certain, that the work, when completed, will secure a depth of twelve feet over the bar." This experience cost \$290,900 up to July 1st, 1886, and it is estimated that the completed structures will foot up to \$3,826,437.50, all to secure a channel of possibly twelve feet depth, while the natural depth varies from seven to thirteen feet. The proposition to rebuild 250 feet west of the former site would merely prove to be a repetition of the above experience.

At another of these inlets, where the normal depth varies from seven to nine and one-half feet, and where \$481,250 have been expended up to July 1st, 1888, it is stated that "the effect of the work upon the bar has been insignificant." Here a jetty, having a total length of over a mile, was also built upon the south (the wrong) side of the pass, and was found to have settled over 50 per cent. along the outer half; while the northern jetty has not yet been begun for lack of funds. Had the jetty been built originally on the north side, and in proper form and position, the other would have been useless, and a marked improvement in the channel would have been the result.

This is shown by the temporary jetty constructed by private parties in 1869 at this pass at a cost of only \$10,000. This jetty was but 600 feet long, and built of light, perishable materials, yet so long as it remained it increased to and maintained

the depth in the channel at twelve feet, and as it was gradually broken up by the waves the channel shoaled to its former condition.

Although this precedent was known to and reported upon by several of the engineer officers of this district, they failed to profit by the experience thus furnished. These works were, therefore, started wrong, and they have either wholly or partially disappeared.

Even in pursuance of the jetty system, it is admitted that "it is the history of all jetties that they will in time require extension. No plan should be followed which does not keep in view future extensions." \* \* \* "If two jetties are to be built they should be essentially parallel to each other." \* \* \* And, again, "Whatever difference of opinion there may be as to how much depth will be secured by a single jetty, there can be none, I think, as to whether a greater depth will not be obtained by two."

*Per contra*, one of the highest English authorities in a comprehensive review of jetty harbors on the continent says: "The jetties also, in most cases, were extended in the hope of reaching deep water, which proved fruitless, owing to the progression of the foreshore with each extension of the jetties. Next, artificial sluicing basins were formed to provide a larger mass of water for sluicing, with the additional advantage that the issuing current was nearer and better directed for scouring the entrance. Lastly, dredging with sand-pumps is being largely employed for deepening the channel beyond the jetties. The parallel system has not proved successful in providing a deep entrance without constant works. \* \* \* Parallel jetty harbors are one of the most difficult class of harbors to design and maintain successfully. \* \* \* Sluicing and dredging are the two means by which the entrance to these ports may be maintained and improved. They are both needed, as they possess distinct functions."<sup>1</sup>

Again, the President of the Institution of Civil Engineers, of Ireland, says: "The system so generally adopted in Continental ports, of parallel, or nearly parallel, jetties, extending only to comparatively shallow depths, appears to be radically wrong in principle. Their tendency generally is to act as groins,

---

<sup>1</sup> *Harbors and Docks.* By Sir Vernon Harcourt, Oxford, 1885.



and make the sandy shore extend outward until the sand passes around the pier-heads, where the action of the sea heaps it up in the form of a bar."

Whilst there are a few instances of the success of parallel jetties, notably at the mouths of the Danube and the Mississippi, it will be observed that the bars at these points are delta-bars, that there is little or no tide, with no inner bays, and that, consequently, the ratio of tidal prism to fresh water discharge is very small and by far the larger volume of flow is seaward. These conditions do not obtain where there are large interior bays or lagoons which must be filled at every tide to maintain the scour over the bar, and where every structure placed on the bar becomes more or less of an obstruction to the influx of the tide.

For this reason the dike proposed a few years since for the improvement of the entrance to New York Bay, and reaching from Coney Island in a south-southeast direction for about five miles towards Gedney's Channel, would, if built, have proven more injurious than beneficial. It was estimated to cost about \$5,000,000.

The causes for the degradation of this most important entrance are the sands traveling northward along the Jersey coast, and westward along the Long Island beach, with the flood tide. Thus the comparative surveys of Fire Island Inlet<sup>1</sup> show a westward progression of the shore line amounting to two miles in about fifty years. At Rockaway Inlet there is a similar movement, which is also observable at Norton's Point, the western extremity of Coney Island, but not to so great an extent, due to the eroding action of the ebb cross-currents from the upper bay.

On the other hand Sandy Hook has increased a mile and a quarter in length within the century, and the sands which are unceasingly transported to its extremity are now distributed by the ebb currents through the Main Ship Channel over the submerged banks surrounding Gedney's Channel. Under these conditions dredging can furnish but temporary relief, yet it may prove to be the most economical of the several methods available at this particular site. To effect a radical improvement here the encroachments of the beach sand must be arrested.

---

<sup>1</sup> See *Franklin Institute Journal* for April, 1889.

Dikes or jetties in pairs, at this entrance, would be the worst possible expedient.

The commission of the Waterstaat of Holland say: "It is to the action of the tides mainly that the maintenance of the depth in our river mouths must be attributed. The total effect depends upon the *velocity* and *volume*; both increase with the tide-range, that is, with the difference between high and low water. If these cannot be increased sufficiently to maintain a profile adequate to the needs of commerce, the end can only be attained by dredging or by a resort to artificial canals."

It is evident, therefore, that any dikes or jetties which would limit or interrupt the tidal oscillation would to that extent prove injurious to the channel, and the greater the tidal range the more serious do such obstructions become, yet the jetty system is the one which is almost universally resorted to as the panacea for insufficient water over the bars.

Some idea of the magnitude of the works now in progress in this country may be obtained by a review of the expenditures upon a few of our Atlantic and Gulf ports, as given in the accompanying exhibit.

LOCALITY.	COST TO JULY 1, 1888.	ESTIMATED TO COMPLETE.
Aransas Pass, Tex.....	\$481,250 00	\$1,668,500
Pass Cavallo, Tex.....	290,000 00	3,826,437
Galveston, Tex.....	1,825,278 83	6,752,721
Sabine Pass, Tex.....	548,750 00 appropriation.	2,051,250
Mobile, Ala.....	978,830 00	276,000 by dredging
Pensacola, Fla.....	215,000 00	25,000
St. Augustine, Fla.....		1,467,888
Jacksonville, Fla.....	732,000 00	576,500
Fernandina, Fla.....	306,782 64	1,592,023
Brunswick, Ga.....	92,463 27	100,000
Savannah, Ga.....	1,032,000 00	6,660,000
Charleston, S. C.....	1,482,500 00	1,525,000
TOTALS.....	\$7,984,854 74	\$26,521,319

These works have been in progress for periods of from ten to twenty years, yet none of them are completed. At this rate of making appropriations it will require from thirty to sixty years to complete them, and there can be no question that the cost is greatly augmented by the scour induced by this temporizing method of doling out the funds.

In those cases where only one jetty has been started and that on the wrong side, no beneficial results are manifest. Where two have been built to high water, a slight but tempo-



rary improvement is noticeable, during the transition stage, as the crest of the bar is moving seaward and the groins are filling preparatory to the general advance of the foreshore. In these cases the main benefit is due to the protection afforded the ebb channel by that jetty which intercepts the sand movement. In the most prominent cases, as at Galveston and Charleston, there have been no important improvements in depth over the outer bars. At Pensacola and Mobile the improvement is due to dredging and is not permanent.

Thus far attention has been directed to the physical conditions surrounding the problem, and space will not permit an expansion into the legislative or executive considerations. These have already been ably presented by experienced and competent economists, and it is therefore not a matter of surprise that at length the subject is beginning to attract the attention of legislators, who desire, in behalf of their constituents, to secure results more expeditiously by securing some changes in the methods of making appropriations and administering these public works.

To this end the Committee on Expenditures in the War Department, Mr. Laffoon, Chairman, in reporting favorably a bill for this purpose, say: "The time has come to inaugurate a definite policy in regard to national public works, and to provide a specific agency for its execution. The sense of the people and of Congress has shown a steady growth for twenty years in favor of the development of harbors and water-ways. During this time grave objections have been urged against legislative and administrative methods, and these objections have gathered force with each passing year. \* \* \* In legislation it is charged that Congress is not appropriating in harmony with any well-conceived general plan or system; that each work is largely considered as a detached or individual work, without special regard to any other or to any collection or group of works as a whole; that appropriations are uncertain and inadequate for economical results, and often for any results at all; and that the largest and most important national works fail to receive that attention which is indispensable if they are ever to be completed."

"In administration various objections are urged which are largely incidental to the necessary methods of organization of

a military body, and that are not adapted to a strictly civil work and function. \* \* \* A necessary, and the larger part of the technical force, is without proper recognition, tenure of position or hope of advancement, resulting in constant change in personnel, as some experience is acquired. The military system does not readily adapt itself to the best civil practice, nor is it desirable that it should if the corps is to remain a part of the army." \* \* \* "The truth of these allegations, to a greater or less degree, is acknowledged by every one. They can be indefinitely multiplied and expanded and have been ably presented to your committee. Great good would come by changing the legislative practice, likewise by a specific adaptation of the administrative organization to its work."

The importance of such changes as are proposed becomes the more apparent when it is seen that the policy of present methods leads to a reduplication of the unsatisfactory Continental experiences, at great waste of time and expense, while the fundamental requirements of admitting the flood tide freely, defending the ebb channel from the encroachments of the beach sand, conserving the ebb discharge for scour over the bar and providing an ample water-way for navigation, are very imperfectly fulfilled by the jetty system as at present applied.